WHITE-LEAD
ITS USE IN PAINT

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PREFACE

As far back as we have written language we find mention of lead. Its most common ore, galena, which is brilliantly crystalline and about as heavy as metallic iron, is found in almost all parts of the world; the readiness with which the metal may be obtained from it is shown by the fact that the early settlers in this country used to set fire to a fallen hollow log and put some of the ore in the burning concavity, in the bottom of which enough melted lead would accumulate to furnish them with material for bullets; while the Indians made a fire over a bowl-shaped hole in the ground and by putting the lead-ore on

the fire they secured lumps of metal from the hole under the fire-place, to sell to the traders; as it is about half as heavy again as iron, and may easily be cast or beaten into almost any form, it is not surprising that it should have been known to the ancient races of men. It is spoken of in the book of Genesis, and in the book of Ezekiel it is noted that fire will burn it to dross, which is litharge; and various uses of it are mentioned in the Old Testament. The Assyrians used it, as we do now, to secure iron bolts in holes drilled in rocks and building-stones; the Greeks, and probably many other nations of antiquity, were acquainted with white-lead and red-lead. The Romans used lead-pipe for city water-works, and understood not only soldering, but the more difficult art of lead-burning, which consists in fusing together two adjacent edges of sheet-lead with a blowpipe; and in the middle ages, sheet

lead was frequently used, as it is somewhat rarely now, for roofing material. From that time to the present, the increase in the variety of uses for this metal have merely been such as has taken place with use of materials of all sorts, as civilization and knowledge have progressed. It is now used in antifriction metals; as packing for pipe-joints; stained glass in windows is bound together with leaden kames; lead wire makes fuses for electric light wiring; it is a necessary ingredient in rubber wares, and in enamels and vitreous glazes; type-metal contains it, and storage-batteries; young men use it to weight the lines for catching fish, and ladies use similar weights in the hem of their skirts to give them an attractive appearance, and in all cases it gives satisfactory results; but the largest single use is in white- and red-lead for paint.

In the Prologue to the Canterbury Tales, written about 1386, Chaucer enumerates among standard medicinal drugs quicksilver, litharge, brimstone, ceruse (i.e., white-lead), and borax, which is the earliest English mention of lead compounds for this purpose that has come to the writer's notice. About 1525 the celebrated physician, Paracelsus, who first systematically used chemistry in medicine, speaks of white-lead, litharge and red-lead as well-known and necessary medicines, and in 1585 a medical treatise by Lloyd says that white-lead dropped into the eyes takes away the pain and clears the eyes. But in general it is spoken of as paint; and paint does not appear to have been used as a preservative, as we use it now, but primarily for decoration; and especially as a cosmetic. From this latter use comes the implied meaning of deception; thus Chaucer, in the Parson's Tale: "Paint thy confession by fair

words to cover thy sin," and in 1456 Sir G. Haye: "This story is painted in many places"; in 1519, Horman: "They white their face and neck with ceruse"; in 1599, Chapman says: "She is very fair, I think she be painted"; and Hexham: "To paint one's face as gentlewomen do"; and Fletcher in 1622:

> "I dare tell you
> To your new cerused face, what I have spoken
> Freely behind your back."

Early references to white-lead for painting walls always refer to interiors, and to their decoration with pictures. As a preservative its use is chiefly on wooden houses, most of which are to be found in America; and sanitary considerations, which now have great influence in promoting its interior use, had little weight seventy-five years ago. Regard for decorative effect still is perhaps the great-

est single cause for the use of house-paints; but people who live in neat and well-painted homes are likely to be more neat and clean in habits and person than those who do not, and hence enjoy life better and live longer.

Whatever may be the cause, the fact is that the use of white-lead is growing at a rate which surprises and sometimes disconcerts its makers, who at this writing are unable to meet the public demand; and the following pages are for the instruction and guidance of those whose need and use of this material prompts them to seek knowledge about it of a simple but reliable sort, rather than for the chemist and scientific expert. The manuscript was read by half a dozen of the best authorities; and the writer had had before him, as a maxim, a sentence written in 1681 by William Penn to his English associates:

"I have forborn paint and allurement, and writ truth."

A. H. S.

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WHITE-LEAD

Early Method of Manufacture

White-lead is one of the oldest manufactured pigments. It is mentioned by Xenophon, who wrote 400 years B.C.; it was well known to Roman writers about the beginning of the Christian era; and the earliest accounts say that it was prepared by putting wine or vinegar in a jar, then some twigs to keep the lead above the vinegar, and finally some plates of lead; then it was covered to keep out dirt, and buried in stable manure, which by fermenting produced a gentle heat (and also carbonic acid gas). After a considerable time the jar was opened and the lead plates were found to be thickly covered with

white-lead. It was expressly mentioned that if wine was used, the heat would turn it into vinegar, so it made no difference whether wine or vinegar was used. This is essentially the old (and modern) "Dutch process" for white-lead; it is within the memory of the writer that spent tan-bark took the place of stable manure.

Old Dutch Process

The greater part of the white-lead made in this country and abroad is still made by this process. As operated here the essential piece of apparatus is the jar or "pot," which is of hard and strong earthenware, ten inches high and six in diameter, the lower three inches of height being smaller than the cylindrical upper part; this smaller lower portion is also cylindrical, with a flat bottom so that

the whole will stand firmly; there is thus a flat shelf within at the bottom of the upper and larger part. About half a pint of weak acetic acid (about 2½ per cent acid, about half as strong as table vinegar) is put into the lower part; and on the shelf-like bottom of the upper part plates of lead are placed, over the acid. These plates are cast and are about five inches in diameter and three-sixteenths of an inch thick, just large enough to go into a pot easily, and each has six or eight good-sized holes in it, so that when laid irregularly one on top of another the air can circulate freely.

To help the circulation of air there are two large holes, opposite each other, in the middle of the large upper part of the pot, and a smaller hole in the upper part of the part which holds the acid. The plates are of cast lead because sheet lead is too compact to corrode evenly. The lead plates are

called "buckles," from an imaginary resemblance in shape to an old-fashioned round shoe buckle; they are very bright and shiny when newly cast. They are laid in a horizontal position one over another until the upper portion of the pot is filled with them.

The white-lead manufacturer buys these pots by the hundred thousand; the breakage is a large item.

The building where the corroding is done is called the stack-house, and has a central open wide hall or passage-way, wide enough for a truck to drive through, and on each side are rooms about twenty by forty feet in area, and the whole place is about thirty feet or more in height. The back side of these rooms is a wall of the building; each lateral side is a partition between one room and the next; but the front, which is next the great central passage-way, is made of long loose wooden planks which are put in

place one by one, as the layers of pots are built up.

First, about two feet of spent tan-bark (which is waste from a tannery) is spread over the floor of one of these sections or rooms as they have been called,—actually such a room is called a "stack,"—it is sprinkled with water, and made as compact as possible; some of the before-mentioned planks are used to build up the front side, as the tan is put in; and the whole of this artificial floor of tan-bark is covered with pots, setting them close together, with the exception of a margin of about fifteen inches all around next the walls, which is filled with more bark, as insulation.

As these pots are put in a man fills the necessary amount of acid in each one from a hose connected with an acid tank, and other men fill the pots with lead buckles, by hand. When all are filled, boards are laid

on the top of the layer of pots, then a second layer of boards to cover the cracks of the first layer; and then fifteen inches more of tan-bark is spread on this floor, and another layer of pots is set, and so on, boarding up the front side with the planks from time to time, until the top is reached. As each layer of pots is boarded over a wooden vent-pipe is put in which goes vertically through the whole mass, to secure proper ventilation. Thus the stack is set. The moist tan-bark ferments, giving off carbonic acid, and generating heat until the whole stack has a temperature of 160° to 180° F., and the interstices of the whole mass fill up with a mixture of air, carbonic acid gas and water vapor. The heat causes some of the acetic acid in the pots to vaporize, and it attacks the lead, forming a basic acetate, which in turn is decomposed by the carbonic acid and water, making basic carbonate, which is

white-lead. The acetic acid, meanwhile, is set free, and attacks a fresh portion of lead, to give place again to more carbonic acid, until all the lead has been converted into carbonate.

Carbonic acid does not act on metallic lead, but it does decompose the basic acetate of lead which latter is formed when the acetic acid vapors reach the "buckles" of the metal; and thus white-lead is formed, while at the same time the original acetic acid is set free to attack the next portion of metallic lead in the "buckle," and thus the somewhat complicated process goes on continuously until the carbonic acid, with which the air in the stack is saturated, combines with all the lead there is; and in the end the acetic acid is all left somewhere through the stack, except what has gone off in the vapors through the ventilators.

It takes about three months for all the

lead in a stack to be corroded. As a matter of fact, twenty to thirty per cent (often more) of the lead never is corroded, but forms a metallic skeleton for the white-lead buckle; but after three months the stack is "stripped," the tan-bark is taken off the top, then the layer of boards, then the men pick up the pots, one by one, and empty them into a portable receptacle which is handled by a crane of some kind, and so on until the stack is all torn down. As has been said, there are a large number of these stacks in the stack building, and when one is being stripped another is being set, so the tan-bark from one can be used in building up another. Since the fermentation is a slow process of combustion, some of the tan is destroyed, and an admixture of new is required to take its place. So also some of the pots are broken, and new ones must be substituted.

It looks like a different sort of an enter-

prise from putting some scraps of lead in a wine-jar and burying it in a dung-heap, but really the chemical process is exactly the same, and so is the product.

The contents of the pots is next put into a machine which separates the metallic lead, and the white-lead is then mixed with water and ground in a mill, after which the remaining small particles of lead are removed by running the material through settling tanks. At the same time particles of tan bark and other dirt are floated off from the top. Finally the purified material is freed from water and either packed as a dry powder or ground with a little linseed oil into a paste containing about eight per cent of oil, and this is packed in steel containers for the market.

Such is the method of making "Dutch process" or "stack" white-lead. One or two details will be discussed later.

Carter Process

Second in importance is the Carter process. The metallic lead is melted, and allowed to flow in a small stream into a jet of superheated steam, which sprays or "atomizes" it into fine particles. This finely divided lead is put into a great horizontal wooden cylinder, six or eight feet in diameter and twelve or more feet long, which rests on numerous rollers, so that it can be made to rotate by suitable machinery. As the cylinder is much less than half filled, there is an opening in the center of one end, through which carbonic acid gas and water can be introduced. The lead is first moistened with dilute acetic acid, and then the cylinder is made to rotate and

the carbonic acid is introduced; this goes on continuously for about twelve days, when the lead is found to be converted into white-lead.

It is obvious that this is practically the same chemical process as the other; lead, acetic acid, moisture, heat, carbonic acid; product, basic lead carbonate. In fact, while the ordinary painter does not hesitate to tell of numerous differences, the most experienced experts hesitate to decide from finished products and say which is stack lead and which is Carter. They are very much alike.

Carter lead has never had a chance to get tan-bark or the coloring matter it contains mixed in it and for this reason, if well made, it is a little whiter than stack lead. Stack lead forms in the pot in compact crusts, and unless great care is taken in grinding it will not be as fine as Carter lead, which is made in a rotating cylinder; and no doubt formerly Carter lead was finer as it was commercially

put out. Being finer it took more oil; hence a given weight of it would spread over more surface. To meet this, the stack lead people—some of them—are grinding their product to a fineness and uniformity formerly thought impossible, so that now the best (not all) stack lead is as fine as Carter. If the latter could be sold cheaper than stack lead it would probably drive it out of the market, eventually; but while it seems to be a much simpler and more easily controlled method, up to the present it has not shown much ability to do so. As a matter of fact, it is not as easy as it looks.

In the first place, uniformity in atomizing the melted lead depends on keeping the metal at the right heat, and the steam at exactly the right pressure and temperature (both), and the mechanical structure of the jets clean and perfect; then the carbonic acid is derived from burning coke, and coke is not always

alike; it is purified by putting it through an elaborate gas-washing process, and if something goes wrong there may be some soot or something else go over into the white-lead cylinder; the heavy machinery required wears out sometimes; and the whole process calls for absolutely untiring vigilance at every point, and that is something which costs money and is hard to get all the time at any price, and a spoiled batch is a considerable loss. Not that the stack lead superintendent has "no cares to vex"; he has, a few; but generally speaking, he has a more complacent and cheerful countenance than the Carter man.

French Process

What is known as the Thénard or French process consists in making a solution of acetate of lead and bubbling carbonic acid (obtained, as in the Carter process, by washing and otherwise purifying the gases from burning coke) through the solution. The expectation was that the presence of water would insure the formation of a basic carbonate; but in fact the precipitate consisted mainly of the crystalline neutral carbonate, which is much more transparent than true white-lead; it is said that the process has gone out of use in France, and is nowhere practiced except for special purposes, such as making orange mineral.

Matheson Process

The Matheson process, operated in one American factory, is based on the Thénard process, but has numerous modifications, not all of which are made public. It produces true white-lead, of a degree of whiteness equal, and in the best qualities, superior to the Carter.

"Mild" Process

Of great interest is the Rowley or so-called "Mild" process, which is radically different from any of the foregoing. The lead is first "atomized" or reduced to a state of fine subdivision by spraying the melted lead with a jet of superheated steam, as in the Carter

process; but Rowley aims to get a product of the utmost practicable degree of fineness, which is not aimed at in Carter practice. This pulverized lead, mixed with water, is put in a tank where it is agitated in a current of air for twenty-four to thirty-six hours, and it is converted into oxide, or more generally hydroxide of lead, considerable heat being generated, and the regulation of this is of importance. The oxidized pulp is then put into revolving cylinders, as in the Carter process; but, owing to the lead being in a hydrated state, no acetic acid is used, and agitating it in presence of a current of carbonic acid converts it rapidly into the basic carbonate. The separation of metallic lead is effected, as in the stack and Carter systems, by washing and flotation, but in the Rowley process this is applied to the oxidized pulp before it is carbonated.

Russian Process

It is of interest to note that there has been practiced in Russia a white-lead process somewhat similar, theoretically, to this, in which fine litharge, probably obtained as a by-product, is spread in heaps on the floor of a chamber, where it is wet, and is turned over with shovels by workmen at intervals; it develops heat, and becomes hydrated; then the chamber is filled with carbonic acid; from time to time it is opened and ventilated, and the workmen again turn it over; until finally it is converted into white-lead. This could be done only where labor is very cheap, and also when no regard is paid to sanitary conditions.

Chamber Process

The Chamber process has been long used in continental Europe. The lead is cast in long thin bands or ribbons, about six or more inches wide—they are in fact sometimes spoken of as sheets of lead, but they are always cast lead—and these are hung on racks in a closed chamber, heated to the desired temperature, where they are acted on by a mixture of water vapor, acetic acid vapor, and carbonic acid from burning coke. The operation is about twice as rapid as the stack or Dutch process. It has the advantage that the chamber can be opened from time to time for inspection, the temperature, composition and inflow of gases may be controlled, and (if the gases are carefully washed) no dirt may be admitted. It may be said to be in-

termediate between the Dutch and the Carter processes, but in actual manipulation bears no resemblance to either. The product is very good, but it costs too much, and the process is said to be unsanitary.

Pan-Drying and Pulp-Mixing

It will be noted that in all these processes the white-lead is left at the close of the chemical process as a wet pulp, from which the water must be removed. This is generally done, in America, by pumping the wet pulp lead into enormous copper steam heated drying-pans; when the water has evaporated the dry lead is shoveled out. In some of the most recent plants the pans are so built that they are enclosed, and the workman reaches

in through an aperture and hoes the dry lead over a sloping side from which it falls into a carrier. By using an exhaust fan the dust is prevented from escaping into the room where the workman is. The National Lead Company, which owns the patent on this device, regard it as so successful in the prevention of lead poisoning that it has offered the free use of it to all white-lead manufacturers; this is also true of any and all of its sanitary improvements; an example worthy of being followed by manufacturers in all kinds of industry. But there is another and a remarkable way of getting rid of the water, without using a drying pan. The pulp lead is weighed into an upright cylinder, in which is a vertical shaft with arms to stir the contents; enough linseed oil is added, on top of this wet lead; and when the whole is violently agitated by the revolving shaft it is found that so great is the attraction of the

white-lead for the oil, and so little for the water, that the oil takes the place of the latter, and the water comes to the top and runs off, practically all of it. At least only about half of one per cent remains behind. In this way there is never any dust, and great economy of labor. Such lead is said to be pulp-mixed, as contrasted with pan-dried white-lead. It has a whiter appearance and a softer texture; its working qualities, under the brush, are a little different from pan-dried lead, and some painters prefer one and some the other, according to which they have become accustomed. Really, if properly used, there is no difference between them in paint value; there may be in ease of working, and the writer has a prejudice in favor of the pulp-mixed variety.

But this opinion is not held by everyone. Some well-known writers declare that pulp white-lead contains a considerable amount of

acetate of lead, which is regarded as injurious. Now, if this wet pulp, instead of being put into the agitator, had been pumped into a drying pan, all the water would have been evaporated, and all the acetate of lead it contained would have been left behind; while in the pulp-mixing, this water runs off and carries its content of acetate with it; so much for that point. Another statement is that if a little pan-dried lead paste is spread on part of a glass plate, and beside it a little pulp-ground paste, and the plate exposed to hydrogen sulphide, the latter will be blackened before the former. This is obviously because the one contains a little water, which absorbs the gas and transmits it to the lead. But when the same lead is used as a paint and spread out in a coat not more than two one-thousandths of an inch in thickness, the minute amount of water it contains evaporates long before the paint has begun to set,

and when it is gone it cannot do any harm. It is not a question to be settled by any quick-acting laboratory test. The fact that tens of thousands of tons of such white-lead are made every year, and that it is generally preferred, as it undoubtedly is for all purposes, in the great city of New York, is a sufficient answer to any such questions.

Washing of White-Lead

There is another point of some theoretical interest. In all these processes which have been described the white-lead has been long and persistently washed; not for the purpose of removing the acetate of lead which it may contain, but to get rid of minute bits of metallic lead, of coarse particles which may

have escaped the water grinding mill, and the loose dirt which may be floated off; but incidentally all the acetate which can be washed out is also dissolved away. So when it is finished it is almost free of acetate; and nobody thinks about it. But for some unknown reason for the last fifty years and perhaps more, nearly everyone who has written about white-lead has said that it is very important that all the acetate of lead should be removed, or the paint will be inferior in various ways. No one has ever explained why, nor propounded any theory; but apparently someone said it one or two generations ago, and ever since it has been repeated; and as white-lead seldom has any considerable amount of acetate in it, it offends no one, and it sounds like a learned thing to say. No one seems to reflect that dry acetate of lead has been ground into all sorts of paint for a drier from remote times, and nothing has

happened; it is the most harmless drier that can be used; a lot of it must be used to get any result. As a matter of fact, acetate of lead up to as much as five per cent is a good thing in white-lead; the paint so made remains whiter, chalks less, lasts longer, and is better paint than that which does not contain any. It is not a little difference either. The writer has seen a wall which had been painted partly with white-lead containing acetate, and partly with the ordinary sort, side by side, in the busiest part of the city of Brooklyn, and after eight or nine years the difference in color and general appearance was plain to any observer, at a distance of a hundred feet or more. And within the last fifteen years innumerable tests between the two have been made, and they come out the same way every time. It is a simple experiment; dry a little lead acetate, enough to make one or two per cent of the lead you

are going to use, grind it well with the lead and make a paint; use the same lead without the acetate and paint them out, side by side. You cannot make it come out any other way. It is not a matter of much practical importance, for nobody is going to increase the cost of white-lead by going to all this trouble and expense, but it shows—well, it shows several things.

Fineness

Fineness is a very desirable quality in a pigment. Some chemical precipitates are very fine; others relatively coarse. Finest of all paint pigments is lampblack, which is precipitated from a decomposing gas; but there are great differences in fineness in lampblacks, dependent on the nature of the gas

and the conditions in which it is formed and collected. Prussian blue is one of the finest water-precipitated pigments. Attempts to estimate fineness by microscopic examination are most uncertain and unsatisfactory; but of course the microscope is a valuable aid, if judiciously used and intelligently interpreted. In the Proceedings of the American Society for Testing Materials in 1910 Mr. G. W. Thompson, chief chemist of the National Lead Co., describes and illustrates an apparatus called a "classifier" (not patented), which is the only means known to the writer for determining the proportion of coarse and fine particles in a pigment, and when used in connection with a microscope it affords a practical as well as a theoretically correct method for classifying pigments as to their average fineness, as well as (what is equally important) the percentage of relatively coarse particles which they contain. It separates the

particles of differing sizes by floating them in a current of water or other suitable liquid, the coarsest particles being collected first, and so on; the method being really one which has long been used on a large scale, but reduced to laboratory proportions and arranged for accurate and proportional measurement.*

In the process of manufacture the wet white-lead after it has been ground in water but before it has been ground in oil, is washed through a screen or sieve of No. 21 silk bolting-cloth, the openings in which are about one one-thousandth of an inch in diameter. Really they are considerably less than this in new cloth, about one thirteen-hundredth of an inch, but after it has been in use the threads become worn and the former figure

* It is described in the "Proceedings" referred to; also in "German and American Varnish-making," by Sabin, published by Wiley & Sons, N. Y.; pp. 200–212.

is probably about right. Therefore the coarsest particles should be only of that magnitude. But an oblong particle will wash through a hole of its smaller diameter and some few of these may be a half longer than that measurement. Of course that is small; but when we consider that a coat of paint is only two one-thousands of an inch thick, and has places where it is less, these particles come pretty near reaching through it; whereas the ideal paint film has several or many layers of particles in it. Hence the desire of the manufacturer is to reduce by grinding the pigment to a much smaller size than this. The "classifier" enables the inspector to learn whether the factory is doing this or not, and to determine the exact percentage of these maximum size particles, as well as that of the ultimately fine ones. The company with which Mr. Thompson is connected operates numerous factories, and for

several years they have each sent in daily composite weekly samples for inspection, with the result that they have lessened the proportion of these larger particles in some cases as much as nine-tenths of the earlier percentages. This has been done partly by greater care in grinding and partly by a better system of flotation. These so-called coarse particles do not appear to be crystals, but little fragments of crusts of white-lead which formed on the "buckles"; they can easily be broken down into a fine powder, but in some way they have slipped through the mill as little compact lumps. Since there is no affinity between this substance and water, the latter does not penetrate and soften them, as it would similar lumps of clay; but afterward when the lead is ground with oil in another mill it is probable that most of them are broken down. At all events nearly all the particles in a well-made white-lead are exces-

sively fine, enough so to meet any requirements of the painter's art.

Opacity

It is the most opaque white pigment used in paint, as is well-known. White zinc is perhaps as opaque, particle for particle, but it requires from one and a half to twice as much oil to make a paint, hence the film has less pigment in it and it is generally allowed that it takes from three to four coats of it to equal two of lead. The opacity or hiding power of white-lead is known to everyone.

Adhesion

In adhesiveness to the underlying surface it also is unsurpassed, and is equaled only by red-lead. White zinc tends to scale off, and the makers of it advise that it be mixed with white-lead enough to overcome this tendency. White-lead never comes off, unless from the fault of the surface to which it has been applied.

Water Resistance

In resistance to water it is also unequaled. Its repellent qualities toward water, as well as its attraction for oil, have been pointed out in describing pulp lead. There is no other pigment except red-lead, known to the writer,

which can be mixed with oil when it (the pigment) is wet; all others, if even moist, need to be dried first. This is a matter of the utmost consequence, since a paint is so generally used to withstand rain and moisture; and is probably the most weighty reason for its remarkable durability. Some years ago an old iron bridge known as the Hammersmith bridge, in London, was taken down, and the metal being still in good condition the engineer in charge took pains to find out what paint had been used on it; there were some parts of the surface which had never been touched since it was built, sixty-seven years before, because they were inaccessible; and chemical analysis showed the paint to be pure white-lead. A paint that will last and retain its protective qualities so long a time as this, in such a trying climate, and over a river crowded with boats, certainly is durable.

Natural Affinity between Lead and Oil

The affinity which exists between lead and oil is not to any considerable extent chemical in its nature; that is, these substances do not unite chemically to form new substances. This is shown by the fact that the oil can be removed from paint or paste lead by the use of solvents, such as ether, or even gasoline, which dissolve the oil but not the white-lead; and after evaporating off the solvent, the oil is recovered, and the white-lead is a dry powder, just as they were at first. It is like the attraction between water and wood; it is a very old practice to drive dry wooden pins or wedges into drill-holes in rock and then pour water on them; they absorb the water, swell, and split the rock. But the water can all be dried out of the wooden

wedges again. This kind of attraction is a very real and powerful thing, even though we do not know much about the cause of it.

When we fill oil full of fine particles of white-lead (or red-lead) this attraction holds the film together, makes it stronger and more elastic, and prevents the fresh, wet film from breaking, and thus is a great part of the cause of its easy working under the brush. It can be laid on thick or thin, with much or little oil, flat or glossy, and is adaptable for all sorts of work.

Proportions of Lead and Oil

Nearly all white lead is sold as a paste containing about eight pounds of oil and ninety-two pounds of white-lead in a hundred. But the proportions vary; some manufacturers use more oil, nine and as high

as ten pounds, and eleven pounds is an authenticated figure, although this was probably due to a mistake or to carelessness. Ten per cent of oil was formerly common, but eight is now standard, if there is any standard. It is often said that the finer a pigment is the more oil it takes; but this is by no means certain. Blanc fixé, which is precipitated barium sulphate, undoubtedly requires less oil to make a paste than does asbestine, although it is much finer. The fact certainly is that in recent years lead is ground much finer than it formerly was and the proportion of oil has diminished. Perhaps this is because formerly the lead and oil were heated more in grinding, which makes a more viscid paste when cool, and more oil was needed to overcome this tendency. It is probably true that in making up batches of paste the oil is likely to be measured rather than weighed, which is likely to lead to mistakes when done

hurriedly and by irresponsible workmen. A hundred pounds of average white-lead paste measures about two and eight-tenths gallons, or about thirty-five and six-tenths pounds to the gallon; these are not the theoretical figures, because in grinding an appreciable volume of air becomes mixed in with the paste, which increases the volume a little, and there is some irregularity about it; it does no harm and as white-lead is sold by weight it does not count. In fact oil is generally worth more per pound than lead.

Durability of White-Lead

More than fifty years ago a celebrated Belgian chemist named Stas announced a theory that the reason why white-lead is more durable than white zinc is that as one-

third of the white-lead molecule consists of lead in a basic condition the acids of linseed oil were able to combine chemically with it and form a linoleate or lead soap; and this being an insoluble and tough substance gave strength to the film and made it waterproof. This sounded perfectly reasonable. All metallic soaps are insoluble; and the oil is chiefly a combination of fatty acids with glyceryl, and always contains some free fatty acids, in varying amount. But it is like the acetate of lead notion; it isn't so. In a hundred pounds of paste white-lead there are ninety-two pounds of white-lead and eight pounds of oil; enough lead to unite chemically with all the oil, and have some left over. But if we shake up some of the paste lead with ether, and let it settle, we find that the ether has dissolved out the oil, and if we pour off the fluid and let the ether evaporate we get back our oil practically as we

put it in; and the white-lead is left, dry white-lead, just as it was at first. Indeed, the oil has usually more free fatty acid than it had at the start. So there seems to be no ground for thinking that white-lead acts chemically on oil, to any considerable extent. It is true, as has been said before, that there is a strong attraction between the two, which we are not able to explain fully, with our present knowledge; but it is physical, not chemical. This attraction, and the concurrent repelling of water, as has been described, is probably a principal reason for the superiority of white-lead as a paint; and along with it, no doubt, is the fact that much more white-lead, not only by weight but by volume, can be mixed with a given quantity of oil (e.g., a gallon) to make a paint of standard consistency; for the pigment is what makes the oil into a paint and the more we can get in and still have the consistency right, the more firm and sub-

stantial will be the film and the better it will resist the weather.

Viscosity and Plasticity

The viscosity of a liquid is the internal attraction among its particles which prevents perfect freedom of vibration, and makes it resist instantaneous changes of form; thus oil is more viscous than turpentine, and water less so than molasses and glycerine. Pitch is a viscous substance; if we spread it on a non-porous smooth surface which is in a vertical position it will more or less slowly run down. But putty, although a yielding material, is said to be plastic rather than viscous; we use it to fasten glass into window-sash and it never changes its shape, while if we were to melt rosin and as it slowly cools

we place it on another glass and sash, in the same relative place and form as the putty, although when cold it is much harder than fresh putty, it will slowly but surely run off completely. The rosin is viscous but not plastic, while the putty is plastic but not viscous. Yet if we put putty on a hard surface and press on it with another hard substance it will squeeze out; that is, it flows if enough pressure is applied. That is what characterizes plastic substances; they behave like rigid solids if not under pressure, but they flow if sufficient pressure is applied, and the amount of pressure necessary measures their plasticity.

Now, oil is a viscous fluid; we may easily spread it with a brush on glass or metal as thin as one one-thousandth of an inch, which would be at the rate of 1600 sq. ft. to a gallon; and if the surface is vertical, it will run down. We could spread putty on such

a surface fifty times as thick and it would stay where it was put; it is not a fluid. Now if we paint such a surface with a good paint with a film twice as thick as the thousandth-of-an-inch oil film it will never start to run any more than the putty; but if we put on a very heavy coat of paint it will run. So paint answers to the definition of a plastic substance rather than a fluid. It is rather disconcerting to think of a paint as a plastic solid, but that is what it appears to be. It stays put unless there is enough weight (pressure) to make it run. This may not seem to be of much practical importance, but if we are going to study paint with the idea of understanding its nature we want to start with the truth whatever it is.*

* This theory of the plastic quality of paint was first proposed by E. C. Bingham and H. Green.

Mixing of White-Lead

Paste white-lead is only a little more liquid than putty, and the first thing to do when it is to be used is to thin it; generally with more oil. If we have a hundred-pound package, for instance, and wish to add two gallons of oil and two gallons of turpentine to it, we do not begin by mixing the oil and turpentine in a tub and then put the hundred pounds of paste in; if we did, we should find when we began to stir it that the latter would stick together in lumps, and persistently refuse to be mixed with the liquid. Instead we put the lead in the tub first and then add a little oil and with a strong wooden paddle (or a large steel spatula) work the paste lead and the oil together, so as to soften the paste, and mix it thoroughly so that it will be

all alike. Then add a little more oil, and do it again; keep on until the paste is fluid enough so it can easily be stirred in any direction, but still is thick like a paste, not a paint; just so that it will pour easily. If any tinting color is to be added, get it, separately, into the same consistency, and at this stage add it to the lead, and mix well. But it is to be remembered that if a formula is being followed it is well not to put in all the color at once, because colors prepared by various makers differ in strength, and it is easy to add too much; it is better to add too little, and see if the shade is right, and complete by putting in the remainder a little at a time. To see what the color is, spread a drop of the well-mixed paste on a piece of clean glass and turn the glass over and look at the paint through the glass; this gives a smooth, perfect surface; and it may be compared with another paint by spreading a drop

alongside, and where the two come together the slightest difference will be manifest.

It is a common practice to put the drier in next, so that it shall be well mixed; then work in the rest of the oil, and finally stir in the turpentine. It should be remembered that drier acts only on oil, and should be proportioned to the oil, not to the total volume, nor to the oil and turpentine.

Paint is better if allowed to stand a day before using; and it should be strained through a fine sieve, or better through cheese-cloth, shortly before it is wanted on the job; this takes out paint skins as well as dirt and lumps, and ensures good mixing.

These directions should be followed strictly; for if the paint is not well mixed it will be impossible to do a good job with it. Always let it be remembered that turpentine is a thinner or more mobile liquid than oil, and that a quart of it will thin a

batch of paint as much as two quarts of oil. Its use is two-fold; it penetrates pitchy wood much more than oil, and will carry the oil into the wood to some extent, hence it is used in priming coats; second, it is sometimes desirable to have a larger proportion of pigment in a film than would be contained in a workable mixture with oil alone, and in this case the liquid part of the paint is part turpentine, which evaporates when it is spread out in a film and leaves the desired proportion of pigment and oil to dry.

Are Colors Affected by White-Lead?

It is often said that white-lead causes certain other colors to fade or change color. If mixed with a rather unstable sulphide like mercury vermilion, this will no doubt occur; it is said that if mixed with lithopone it will

be blackened by the sulphur in the latter, but this is doubtful. There is no reason why it ever should be mixed with lithopone; both are white; but in the laboratory with which the writer is connected the experiment has been tried repeatedly and no discoloration has ever taken place, even after years of exposure. It is frequently said that it cannot be used with chrome yellow, chrome green, or blue. As to the first, the mixture of white-lead with chrome yellow is the well-known and favorite house-paint, colonial yellow; more durable than white-lead itself. As to green, it must be observed that chrome green is a very intense and powerful color, and if used alone produces a shade too dark to be liked except for special uses; and if it is diluted with white-lead, as in light shades of window-blind green, there is so little of the green that it easily fades by the action of the sun. The Prussian blue is a very unstable

color by itself, and as has been said chrome green is a mixture of this blue with yellow. While undiluted chrome green is a fairly permanent color it is so because there is so great a quantity of color present; the blue, though an intense and powerful staining-color, is lacking in opacity, and this helps to maintain the color when it is used pure or in large proportion; but not when thinned with a highly opaque white, like white-lead. So it is extremely doubtful if the latter has any active effect on these colors; but, of course, the result is the same, that is, the light shades of green and blue made with it fade easily; but not yellow. There is no way, in fact, to make these light tints fast to sunlight; some more permanent colors should be used.

Discoloration of White-Lead

It is often said that white-lead is liable to be discolored (blackened) by sulphur. As a matter of fact, exposure of white-lead paint for a considerable time to hydrogen sulphide (sulphuretted hydrogen) will blacken it. This gas is evolved by what are commonly called "sulphur springs," which are found in many places; but in the course of a fairly long and certainly much-traveled life the writer has never seen more than a couple of dozen at the most, and the amount of white-lead that has been discolored from that source is negligible. It should not be used on the interior of a general chemical laboratory. There are a few cases when untreated sewage is discharged into a small or sluggish river and

this gas is given off in quantity sufficient to discolor buildings on the bank; but such cases are rare. It is not probable that one thousandth of one per cent of white-lead used in paint is ever discolored by sulphur, so it is not worth talking about. Any light-colored paint may be discolored by ammoniacal fumes rising from neglected stable manure, but this is probably due to the action on the oil; stable manure was used for generations as a bedding material in making white-lead, so it can hardly be supposed to act injuriously toward it.

White-lead paint becomes yellowed in the dark, that is, if painted on a surface which is continually in a dark place. Any such discolored surface will at any time bleach out white if exposed to the sunlight. In the interior of a house it does not sensibly discolor in ordinary well-lighted rooms. Linseed oil is itself pale yellow in color, and freshly

painted white-lead is not absolutely pure white, but it rapidly bleaches, and no paint can be whiter than white-lead is on the outside of a house. All white paints yellow somewhat in the dark, but lead more rapidly than zinc, for example.

While the chemical rays of the sunlight bleach oil paints, at the same time they slowly attack and decompose the oil; and white pigments allow the light to penetrate more than colored ones (except blue) do, hence brown, red and yellow colors are more durable than white. It is a well-known fact that houses painted colonial yellow with white trim show the deteriorating effect of age more quickly on the white than on the yellow. Anyone who has ever dabbled in photography knows that yellow and red and of course brown and black, are insensitive to the chemical light-rays. Consequently, unless the colored pigments are much worse material for paint

than white, they last longer. Some of the reds based on dye-stuffs are perishable, as also is mercury vermilion; but some of the dull red and brown oxides of iron and some of the blacks will outlast any white paint that ever was made.

Chalking

Now, it is not the pigment that is decomposed, but the oil, which is a very complex substance. If protected from direct sunlight it will last; there are oil paintings hundreds of years old; but when pure white-lead, for instance, is exposed to direct sunlight, after a time which sometimes is one year and sometimes two or three it loses the oil in the outer part of the film, leaving the lead without any binder and this loose lead—not the whole of it but just the surface—will

brush or rub off, as chalk may be rubbed off a blackboard; and painters say it "chalks." Oxide of iron paint does not do this, and consequently it lasts much longer unless some other cause intervenes; but that is the way white-lead perishes, gradually from the surface, without injury to the under layers until the outer ones are worn off. Consequently as long as any of it is left it is in good shape to repaint.

Checking

If the amount of paint is enough to make a thick coating, as the oil decays the surface shows little fine cracks, called checks, making a fine reticulated pattern. These do not for a long time—sometimes several years—go through to the wood, but if they ever do it becomes necessary to scrape or otherwise re-

move the old paint and repaint from the original surface.

Zinc Oxide

No other white pigments exhibit these phenomena of chalking and checking in the way that white-lead does. The question then occurs, why not use some other white paint instead of it, for outside work? It is obvious that there must be an answer to this, or it would not have continued for hundreds of years to be the standard white paint. The fact is that the number of white paints is small, and they all have worse faults, and are less durable. The principal white pigment, next to lead, is oxide of zinc. An ordinary white-lead paint contains at least a half more pigment by volume (much more

than a half more by weight) than an ordinary white zinc paint; and while (contrary to common opinion) a particle of white zinc is probably just about as opaque as the same-sized particle of white-lead, it is plain that a film of white-lead paint will be much more opaque than one of white zinc because there is so much more pigment in it, for the oil is transparent. Naturally once and a half as many coats of zinc paint as of lead are needed to get the same covering effect, and this makes the former the more expensive to use, for the labor of applying a coat of paint is two-thirds to three-quarters of the cost of the job; and furthermore it takes more labor and more skill to use the white zinc. That is one point. The next is, that while it is commonly believed that white zinc does not chalk, it is also common belief that it wears off sooner than lead. The fact is that sunlight penetrates zinc paint and destroys the oil just as

it does with lead; but while all the common lead compounds are insoluble, and hence the lead stays on as long as there is the least bit of binder, the zinc oxide is easily attacked as soon as the protection of the oil is lost, and is frequently if not always converted into a soluble salt, which dissolves and is washed away by the rain, leaving a hard surface without chalk, but the film is growing thinner all the time. Anyone can test this theory on a zinc film, or one containing much zinc, which has been exposed to the weather for a year or two, by rubbing it with a wet finger and applying the latter to the tongue, when the peculiar styptic and astringent taste of zinc salts will be perceived; the "chalk" is soluble in one case and not in the other.

The third objection to zinc is that it forms a very hard and inelastic film which is liable to crack through to the wood and then the moisture gets in behind it and throws it off

in larger flakes. Painters say it "scales." This is admitted by the largest manufacturers of it, who advise mixing thirty-five to fifty per cent of white-lead with it to obtain elasticity and better adhesion to the wood. Painters who use such mixtures generally use two or three parts of white-lead to one of white zinc; if enough lead is used this defect disappears; but the other two remain, of course with diminished effect. White zinc has some excellent qualities; thus it can be used in making white enamels with oleo-resinous varnishes, which white-lead rapidly coagulates.

Basic Lead Sulphate

Next in importance is the basic sulphate of lead, which is also called sublimed white-lead, the latter being a copyrighted name.

The most common lead ore is the sulphide forming the mineral called galena. Lead generally carries in combination an appreciable amount of silver; but when there is a deposit of galena nearly free of the precious metal, the ore may be burned, mixed with a little coke and a suitable flux, in a furnace designed for the purpose, and the oxygen of the intensely heated air which passes through the furnace converts it into a sulphate. Part of the sulphur burns into sulphur dioxide or sulphurous acid gas, and goes off in the atmosphere, but part stays with the lead. Consequently not all the lead is a neutral sulphate; the most plausible explanation is that there is such a thing as a basic sulphate, containing two atoms of lead to one equivalent of sulphuric acid, with a (theoretical) chemical formula of $2\ Pb\ SO_4.\ Pb\ O$, very similar in construction to that of white-lead, which is $2\ Pb\ CO_3.\ PbO_2H_2$; but while white-lead is

a tolerably uniform and constant substance, the basic sulphate product consists of a varying mixture of the above named compound with an indefinite lot of the neutral sulphate, Pb SO_4, the proportion depending on how the furnaces are operated, and possibly on the amount of moisture in the atmosphere; it is not known how to produce an exact proportion; in the commercial product the basic constituent varies from five to forty or fifty per cent. Fortunately, any of it can be used in paint, but fifteen per cent is desired. The neutral sulphate is non-poisonous, and it is likely that the poisonous quality of this pigment increases with the proportion of basic sulphate because some tests have shown it to be less so than white-lead, and others much more so. If made into a paste with oil it hardens, so it is used dry; some of the largest paint manufacturers refuse to use it because it is dusty and the dust is poisonous;

white-lead, being supplied in paste form, is sanitary in this respect. This quality also prevents its use, as a paint by itself, because the painter requires his pigments to be supplied in paste form. It is used only as a substitute for white-lead in mixed paints; it costs less, but it chalks worse, appears to be less durable, and is not as white. It is finer than white-lead, is nearly as opaque, and in not too great proportion its oil-hardening property does not appear to interfere with its use in mixed paints.

Lead Poisoning

Right here it may not be amiss to say something about the poisonous properties of lead paints; in fact it is always in place in a technical book to say something about safety

first in industry, if it can be dragged in. All the lead pigments are poisonous. So are many more; but lead is apparently so only if it gets into the stomach. Acetate of lead solution has been employed as a wash in skin diseases for at least a hundred years and lead plaster is kept in every drug store; so lead is not dangerous when applied to the skin. In fact, white-lead paste is commonly applied to severe burns. But in the stomach it is dissolved and gets into the system and it stays there, and when enough of it accumulates it causes lead poisoning. A sudden attack caused by swallowing a lot of some lead compound is not serious; it causes temporary trouble, but that is all; but the gradual and long-continued accumulation may cause paralysis or even death.

Among the nine or ten millions of people in the State of New York there are only one or two deaths per year—sometimes none—

from this cause, so it may be spoken of as a rare disease; the writer has never met a master painter who regarded it as a serious matter, and a majority of master-painters have never seen a case, although it is almost confined to house-painters. But it is a serious matter for all that, and it is entirely preventable. Men working in dust containing lead get it in their beards, they inhale it in the mouth and nose—there is, as all know, direct communication between the nose and the mouth—they get it on their hands; and this last condition, getting it on the hands, applies to anyone handling metallic lead, as lead pipe, and especially to journeymen painters, who get lead paint on their hands; if they would wash it off it would do no harm, but they do not; they handle tobacco, they eat lunch, with dirty hands, and so they get it into their mouths. Nearly all lead poisoning comes about in the latter way. Of

course the master-painters ought to teach their men about this, and they do; but once in a while there is a man who hates to keep clean. The great lead-manufacturing companies are able to enforce these matters of personal cleanliness; they provide facilities and have the men wash on the company's time, and have inspectors to see that they do it, and that is practical prevention; but a single painter, working on a house by himself, can not be protected unless he does it himself. The dry lead pigments, to be sure, are dusty; but big factories, whether they be white and red-lead factories or those for mixed paints, can provide mechanical means for handling such stuff, so that the dust does not get out; except in cases where small portions have to be weighed out from time to time. White-lead paste, for example, is made of dry white-lead and oil, mixed by a machine that is dust-tight, and the dry

powder is put in by an automatic weighing machine. For five or six years past it has been possible to get red-lead in a similar pure paste, so that now painting ought to be, to a decently clean and careful man, a perfectly healthy business; and it is. The only serious sources of danger now are the places, such as glass, ceramic and rubber factories and the like, where they use dry litharge, white- and red-lead and basic sulphate, and where the workmen do not know the danger from the dust, and no one looks after them; but the state authorities now are taking care of those places pretty well. It is like working around a machine; if you take care of yourself there is no danger, but you have got to exercise reasonable care.

Lithopone

To go back to the subject of white pigments; next in order, after white zinc and basic lead sulphate, is lithopone. This is made by putting together solutions of barium sulphide and zinc sulphate; the two metals change places and we have a mixture of barium sulphate and zinc sulphide, both insoluble, so they settle out, and after washing and drying we get this intimate mixture, called lithopone, which contains about seventy per cent barium sulphate and thirty per cent zinc sulphide. It is, if well made, extremely fine, and about as white as white zinc, and as opaque as white-lead; a remarkable and beautiful pigment. It cannot be used where it will be exposed to the

weather, because it is easily decomposed; no one ever uses it in this way. It can be and is used mixed with shellac varnish (which will not mix with white-lead or zinc) as a quick-drying white enamel for some purposes; but its principal use is as an interior flat finish for plastered walls.

Flat Finishes

It has already been said that "flat," as a painter's term, is the reverse of glossy. That which gives paint a gloss is having a quantity of oil (or varnish) in it, so that when it dries the vehicle (or liquid portion) will cover over the particular pigment and thus reflect light. For instance, imagine a pond with a perfectly flat and level bottom covered

with pebbles. If we have just enough water in it to cover the pebbles, it will, when frozen, reflect light like a mirror. That is like enamel paint. But if we draw off part of the water, so that when it freezes there will be only enough ice to bind the pebbles together, then they will form the surface and, being rough, will not reflect much light. That is like flat paint, greatly magnified. It must be remembered, however, that in real paint the particles, instead of being pebbles or stones which would instantly sink through the water and rest on one another, are really like fine particles of clay, which, though of the same material and actual weight as the rocks from which they are pulverized, float in the river water from the Rocky Mountains to the Gulf of Mexico. In this same way the grains of pigment are separated by the oil, which composes three-quarters of the film; and in the imaginary pond they only

appear to be of material size because we magnify them, but really the liquid is between them, only in onc case much more than in the other, as is also the case in glossy and flat paints. If we bear this in mind, we may imagine that a square inch of paint corresponds to a pond a mile square, filled fifteen feet deep with a mixture of liquid and stones, consisting of pebbles from a quarter of an inch to six inches in diameter and larger stones increasing in dimensions to a few rare boulders five or six feet in size, and all just covered or mixed with liquid. In a flat paint, the particles of pigment would not be absolutely bare, as the pebbles would be, because these particles are so small that they soak up a little of the oil, but the surface would be rough and not glossy.

Chinawood oil began to be known in this

country about 1902-03; and a few years later it was discovered that a varnish could be made with it and common rosin, which could be made very thin with benzine, and that this thin varnish could be used as a vehicle (or binder) with lithopone and when the film of this paint evaporated and dried it made a beautiful and perfectly flat surface; although lithopone has long been known this discovery started its use in this country, and tens of thousands of houses, probably, have had their plastered walls painted with this material. It is cheap, easily and rapidly applied, dries quickly, can be washed when it is new (and doesn't need it) and the vehicle is so thin it does not show brush-marks badly. And it certainly is fine to look at.

The faults of such a coating are partly in the vehicle and partly in the pigment.

Rosin is not a durable ingredient for a varnish; and while it is true that rosin varnishes made with tung (China-wood) oil are much better than any made before it was used, yet an excessively thin film of quick-drying rosin varnish will perish in a few years, or sooner. It is not necessary in such a case as this that it should entirely perish; if it ceases to protect the particles of lithopone which help form the surface the mischief is done, for lithopone is not a very stable substance, as is shown by its inability to zinc sulphate, which is soluble, and when mixed with the best linseed oil; it oxidizes to zinc sulphate, which is soluble and when part of it does this it naturally tends to deteriorate the film rapidly. Soon the moisture gets under it and it peels off in long ribbon-like strips. If a permanent pigment like white-lead could be used, it would not be

so bad, but it will not mix with a rosin varnish, nor will white zinc.

On the other hand, if a permanent vehicle such as a durable varnish could be used, or a good linseed oil, then the somewhat perishable pigment would be protected; but no such a vehicle appears to have been found that will work as the rosin varnish does. All the makers of this sort of

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Page 70, line 13, should read

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metallic powder. Attempts have been made to stabilize lithopone, as for example by mixing an oxidizing agent, such as a nitrate, with it; but none of these appears to have been successful.

In this connection it should be said that within a few years at least two liquids have been put on the market, not varnishes, and free from rosin and apparently consisting largely of a refined and treated linseed oil, probably mixed with some other vegetable oil and with turpentine or a turpentine substitute, which make highly satisfactory flat wall paints with white-lead; but they do not appear to work with lithopone. These new-style flat lead paints have been in use several years on a large scale, and so far appear to be permanent. It is an ancient practice to mix white-lead with four or five per cent of linseed oil and thin the mixture with turpentine; this paint gives a beautiful

flat effect, and is permanent; but it shows brush marks and must be stippled, which consists in dabbing the freshly painted surface with the end of a nearly dry brush; this involves considerable labor cost, but as it is satisfactory when done it is still largely practiced, especially in costly buildings. The lithopone flat paints are so very cheap and so beautiful when new that they have a large use in spite of their defects; perhaps the new style flat white-lead paints will successfully dispute this field with them; many of the best decorators and painters appear to think so.

Leaded Zincs

Intermediate between white zinc and basic lead sulphate is a class of products known indefinitely as leaded zincs. Such are made exactly as the basic sulphate is, but instead of using pure galena a mixed lead and zinc ore is used, carrying from fifteen to forty per cent of lead (in the finished product) and the remainder zinc oxide. Such a pigment is not pure white, but as it is used in colored paints, that is not important.

The makers of ready prepared paints have, many of them, long been using both white zinc and basic lead sulphate in their products, and this natural mixture is expected to take the place of both. A theory has been proposed according to which this is not a mere

mixture but in part at least a chemical combination; and it is certain that some of the most expert paint manufacturers, and their chemists, maintain that it acts in paint mixtures differently from what the mixed pigments do.

Auxiliary Pigments

We now come to substances which may be called auxiliary pigments; they are either white or nearly colorless. This list comprises barium sulphate, which, if artifically prepared, is also known by its French name of blanc fixé, and, if it is the natural mineral pulverized, is called barytes; silica, which is generally powdered quartz; sulphate of lime, which is powdered gypsum, and is called by the paint men terra alba; silicate of magnesia, which is obtained by pulveriz-

ing a mineral related to asbestos, and is often called asbestine, a convenient and descriptive name, but unfortunately covered by copyright; carbonate of lime, which sometimes is marble dust, but should be the powdered chalk long known as whiting, which is the solid part of putty and is used for many other things; and powdered kaolin, known as China clay. These are all alike in two important respects—when mixed with oil they form a film which is transparent or nearly so; and they are cheap. The latter is what causes their use in paints; they may have some other good qualities, but if they cost as much as white-lead they would never be used.

Furthermore, no chemical reason has yet been offered to show why any of this group of pigments, with the possible (and doubtful) exception of terra alba and whiting, should not alone with oil make a durable

paint, a protective if not decorative coating. But none of them does, nor any mixture of them. It would look, then, as if they are simply adulterants; and most practical working painters think they are; but even this is not certain. They are used only in making the prepared so-called "ready-mixed" paints; and to get any reasonable idea as to their use we must give this class of products a little consideration.

Mixed Paint

While it is true that most painted houses are light colored, and therefore are white or painted with a white paint tinted not more than half, at most, are pure white, either outside or inside. While there is no great

mystery about adding tinting colors to white paint, many hesitate to do it, and even among the less expert of journeymen painters there are not a few who cannot be trusted to match colors. To meet this condition numerous factories exist where the paints are put up, not in paste form but thinned ready for use with oil, turpentine and drier, and sealed in tin cans or pails, of the exact colors which are reckoned to be most popular, and painted panels or color cards are furnished to show these tints or colors. The matter of painting is thus simplified and anyone who has confidence in his (or her) ability to handle a paint-brush properly, is able to undertake a job. There is no doubt that the use of such a paint relieves the responsible person whether amateur or journeyman, owner or contractor, of considerable anxiety; for these paints, if well stirred before using, are true to color; and while

the proportions of oil, turpentine and drier are not as variable as could be wished to get the best results in widely-varying exposures, they meet average conditions, and there are always two classes of them, one for outside and one for inside use. They are convenient; you buy just as much as you want, and you avoid a lot of messing and muss. The enormous sale of these paints proves that they meet a real want, and their manufacture, if conducted on ordinary principles of business honesty, is as legitimate as raising wheat.

Volume Proportions

As to what constitutes the best paint different people hold differing opinions. White-lead and white zinc are admitted by

all to be the foundation, but some use all or nearly all lead, and some a large proportion of zinc; some use straight white-lead, others substitute basic sulphate and still others leaded zinc. At least two of the largest makers never use any substitute for pure white-lead (they use pure zinc white when they think it desirable), and one famous house advertises its standard to be pure white-lead and white zinc and nothing else. These people are making good paint; and they get a good price for it, to which they are entitled. The paint men, like everybody else, are after a profit; even the government charges a good percentage for stamping gold and silver into coins; and a manufacturer must consider costs as well as prices. Now the cost of paint is the cost of pigment plus the cost of the vehicle. The vehicle is largely linseed oil; this is worth more per pound, usually, than most pigments,

but it is lighter than water, and by the gallon it is cheap compared with lead or zinc pigments; it takes 55 lbs. of dry white-lead or 46 lbs. of white zinc to make up the bulk of a gallon in a paint batch, so that the part of a gallon of paint that is filled up by these pigments costs at the rate of about five dollars a gallon, at present prices; but it takes only from 19 to 23 lbs. of the so-called "auxiliary" pigments except barytes, which is 36, and for such part of the gallon as these occupy the cost is only thirty to sixty cents per gallon; oil may be reckoned at the rate of say a dollar and a half, and the turpentine half of that or if turpentine substitute is used as it legitimately may be, about a sixth of the specified price for oil. It is therefore desirable, from the cost standpoint, to use as little lead and zinc as practicable, and as much auxiliary pigment and turpentine or its substitute. Sometimes this

sort of thing is carried to extremes; for example, before the "pure paint law" was enacted in North Dakota, "pure white lead in linseed oil" was being sold in that state which had no white-lead and no linseed oil in it; and prepared liquid paints in which twenty-five per cent of the vehicle was water. But that was a long time ago, and we are now talking about legitimate business. It takes sixteen pounds of white-lead and five and a half of oil to make a gallon of paint which is about like, in brushing quality, a gallon made of nine pounds of white zinc and eight-tenths of a gallon of oil (that is, zinc takes twice as much oil as lead to give the same viscosity [or, as Bingham would say plasticity] in a paint, and if lead and zinc each costs ten cents a pound (sometimes one and sometimes the other is the more costly) and oil a dollar and a half a gallon, the lead paint would cost two dol-

lars and seventy-five cents and the zinc paint two dollars and ten cents. because the latter contains less pigment and more oil. So if the maker is thinking only of reducing costs per gallon, he will prefer zinc to lead; but if he is thinking only of durability he will prefer lead to zinc. Usually he uses part of each; and half a gallon of each of these paints would together contain 12½ lbs. of pigment and cost two dollars and forty-three cents.

But if he puts in what he calls fifteen per cent of asbestine, let us see how he will come out. It would take 85 lbs. of the mixed lead-and-zinc pigment and 15 lbs. of the asbestine to make such a pigment as is in question, and the 85 lbs. of lead-and-zinc would make six and four-fifths gallons of lead-and-zinc paint, costing altogether $16.52; but the fifteen pounds of asbestine (which is light and bulky and takes much

oil) will make five, or at the very least four gallons of paint and this asbestine paint will contain about four-fifths of a gallon of oil in a gallon of paint, and if the asbestine costs two cents a pound the paint will cost about a dollar and twenty-eight cents a gallon, or five dollars and twelve cents for the four gallons; adding this to the lead-and-zinc paint we get ten and four-fifths gallons of paint costing $21.64 or two dollars for a gallon which contains only about eight pounds of the mixed lead-and-zinc pigment instead of twelve and a half. Actually he has got less than two-thirds of a gallon of lead-and-zinc paint and more than a third of a gallon of asbestine paint, although the dry asbestine is only fifteen per cent of the total dry pigment. And if in each of these paints he puts in a moderate amount of mineral turpentine, say twenty per cent of the vehicle, the straight lead-and-zinc paint will cost about

thirty per cent more than the one with the fifteen per cent asbestine in it.

These comparisons are very moderate; double these differences can be shown in current practice; but the point is to illustrate exactly how costs can be reduced, with a very plausible composition.

But, it may be said, what the ultimate consumer wants is not analysis and expositions, but paint; good paint; and if the cheaper paint is just as good, that is what he wants. Precisely so. Now, is it as good?

In the first place it will be found that the manufacturer strongly insists that it is as good as white-lead paint containing sixteen pounds of white-lead in a gallon (instead of nine pounds of the three-part pigment) and he sells it for the same price, or more commonly for considerably more. That is, he gets a large gross profit; that may be defended if the paint is as good or better, but it throws a

light on the way the business is conducted. As human nature is constituted, the fact that a large profit is coming in predisposes the man who is trying to make a good article out of cheap materials to think the materials are good, and ought to be used by everybody. This probably has a share in bringing about the practice of numerous manufacturers of making a grade of paint lower than their standard, and sold under a different brand, and at a lower price, for the use of those who consider price as the one important thing; this includes those who are ignorant of what to expect of paint, and also those who like many building contractors undertake to paint a structure and are not tied up by specifications.

There are some things which are susceptible of proof. Thus it may be proved by any careful and skilful workman that the mixing of any of the auxiliary pigments, even in so

small a portion as ten per cent, with white-lead produces a paint which, with the same proportion of oil and applied to an equal surface, is inferior to straight white-lead in opacity or hiding power. Yet this is often denied by those who are advertising the extended material. It is perfectly well known to all practical painters of long experience that paints containing twenty-five per cent and more of these extenders are of inferior durability, and none of the more responsible makers advise more than fifteen per cent; it may be doubted whether the addition to a good paint of any proportion of a poor one improves it. It is however true that white zinc takes what most people regard as an excessive amount of oil to make it into a workable paint, and that by adding barytes or silica, which have very low oil-taking power, the proportion of oil to pigment may be much reduced, the barytes in this single respect act-

ing as would the addition of white-lead, which latter is what the white zinc manufacturers advise; and it is true also that the addition of asbestine or china clay to white-lead makes a composition pigment which takes more oil than white-lead alone, and some have a theory that this is desirable. In one case the barytes acts as a cheap substitute for lead, and in the other the asbestine is a substitute for zinc; and neither would be tried if they cost as much as the pigments for which they are used. But such considerations as these are used as reasons for adding these auxiliary pigments to the more substantial part of the paint. It is really a question for experts to decide; and fortunately there are such, real ones. Nothing tends more to give a man good judgment of a thing than having to work with it every day for his bread-and-butter; and that is what the painters do with paint. There are sixty or seventy thousand

of them in the United States; the best trained of them have a strong organization in almost every state, and a national association; and while a good many of them use ready-mixed paints on occasion, they all believe that for every-day use no light-colored paint material compares for general purposes and especially for durability with that made of pure white-lead, linseed oil, turpentine and drier.

This is no reason why the makers of mixed paints should go out of business; but it is a reason that they should be careful and moderate in their statements, which in some cases have been far from truthful. There are plenty of good reasons why these paints should be sold; besides those already enumerated, which are themselves valid, there is the additional fact that they are sold at a profit much greater than is afforded by white-lead, so that the latter has to be sold for cash, while the others can be sold on credit,

if carefully managed; and the dealer can be given a larger commission, which induces him to urge them on his customers.

Preference of Painters for White-Lead

The writer once visited a paint store, the largest in the state in which it was located, and saw the shelves covered with cans of prepared paints. In answer to questions the proprietor said they had a considerable stock of white-lead in the basement, which they always used in their own contract painting, for which they felt their reputation involved, but they always sold prepared paints if possible, partly because of the larger profit and also they thought them better suited to the rather inexpert people who bought them.

And there are innumerable specialties, such as varnish paints, which can be best made only in a paint factory. But the bulk of the painting done by professional painters is with white-lead.

One reason for this—perhaps the greatest—is that the skilled and experienced painter learns that different surfaces and exposures need various treatment; white pine a different proportion of ingredients in the paint from cedar, and again from redwood; Montana from Florida; the kitchen from the dining room; and for every recognizable difference he may provide if he mixes his own paint. Again, to get harmonious effects, slight differences in hue and shade are required between shaded and brilliantly lighted parts of the same room sometimes; and if he or his customer has a cultivated taste in color, delicate tints and colors may be needed, far beyond the coarse approximations of a

color-card. He considers himself, in fact, as a functionary analogous to a modern physician in comparison with the captain of a whaling-ship who has a chest of medicines and a book; the latter may effect a cure, which is all anybody could do, but the patient would generally prefer to be treated by the skilled and experienced professional. That is, painters take a proper and justifiable pride in understanding their business; and if they prefer white-lead to all other pigments, they are sure to be right; and that they do no one can doubt who ever attended a master-painters' convention.

Brushes

Thus far we have considered the character and preparation of the various sorts of white-lead, and its substitutes; it is desirable to consider its application and use in more detail. It is used almost wholly for paint; and paint is applied with a brush. For many years the standard brush for the larger surfaces in house painting has been what is called the pound brush; originally it was supposed to weigh a pound, but now it is often not more than half of that weight. It is a round (cylindrical) brush, nearly two inches in diameter, with bristles about six inches long when new. Bristles as long as this would spread out too much in use, so they are confined by putting a band, called a

bridle, around the brush, restricting the working length of the bristles to about four inches, or less in a smaller brush. Bridles are sold by the dealers or are made in various ways of cord or cloth by the painters. As the bristles wear off the bridle is moved back, and finally taken off. Bristles should be strong and elastic; if soft and too yielding the brush is not good. A good brush should be of uniform composition throughout and should not have a hollow place in the middle. It is the ends of the bristles that spread the paint, but the body of the brush is a necessary reservoir to hold it, and it must be of such a character that it will hold a considerable amount and not have it all run out at once, but feed it down gradually as it is being spread. Without a good brush which will do this, it is impossible to produce an evenly-painted surface; and money is well spent in buying the best brushes; and they are not cheap. They

should have the best of care. A two-and-a-half-inch oval brush is liked by some painters better than a pound brush; indeed some progressive painters say that the day of the pound brush has passed away, but that may be doubted; a good brush is a good brush, no matter what shape it has. These oval brushes were originally made for varnish-brushes, and the user of fine varnish is willing to pay for the best brush that can be made, which is probably the reason why they are so much esteemed. At all events it is no sign of poor workmanship if a man uses a high-priced oval varnish-brush. For some delicate work the smaller oval and flat brushes are almost a necessity. But there are smaller round brushes from a quarter of an inch to an inch in diameter, of fine quality, which are called "sash tools," which are also extremely useful. Often these brushes, the oval and the sash tools, instead of having the

ends square across have the bristles clipped off so as to form a wedge-shaped end, called a chisel-edge; these are especially for varnishing and delicate work.

It is not unusual to see painters using large flat brushes four or five inches wide, with which the surface can be covered rapidly; but paint should not be merely spread on, it should be brushed in, so to speak, so that the adhesion to the under surface shall be complete, so that there is as little porosity in the coat as possible; and it is too hard work for a man to do this all day with a very big brush. But the inside flat wall finishes (lithopone or white-lead) which have been described, are almost as thin as white-wash, and cannot be brushed very much; wide flat brushes are best for them. Flat so-called camel's hair or fitch brushes are often used for fine varnishing, but they are, as a rule, too soft for paint. Painters also use dusting-

brushes or dusters which are round or oval brushes with three or four-inch stiff bristles, considerably separated, to brush off the dust and dirt before painting; and sometimes, to get off old loose paint, wire brushes, which are like common scrubbing-brushes with stiff elastic steel wire instead of bristles, about three inches long; the brush is three inches by six or eight inches; and of course ordinary scrubbing-brushes are often necessary in cleaning before painting; but the surface must be dry when paint is applied—dry and clean.

Brushes should not be left in the paint, standing on end, as the bristles will be bent and matted. If they are to be left only over night there is no harm in wrapping them well in wet paper and laying them down; but not shellac-brushes, which will dry up somewhat in spite of any care. In general, brushes should be well washed out in turpentine or kerosene and rinsed with gasoline; shellac

brushes in alcohol or in a strong solution of washing-soda and then thoroughly with water. Brushes are also kept in a brush-safe, which is a deep vessel with a cover, within which are hooks fastened to the sides, near the top; the brushes are hung up by their handles to these hangers, so that the ends of the bristles do not touch the bottom, and enough oil or turpentine is put in to cover the bristles nearly but not quite up to the binding. Dust is the great enemy of brushes and must be kept out.

Exterior Painting

White-lead is used on both new and old surfaces; chiefly on wood. All wood is not alike; white pine and white-wood are rather soft and absorbent materials, while Southern

pine contains much pitch which does not absorb oil; cypress has numerous resinous areas and is bad because the non-resinous portions take paint well while the others do not; and redwood is not very absorbent. Oak and other hard woods are not very often painted, but offer no difficulties. Most new work receives three coats of paint; in England the rule is four coats, but three is considered standard in this country; these are called priming, body and finishing coats. The first is supposed to fill the pores of the wood, seal it up and furnish a solid base for the next coat. A little consideration will show that when paint is spread on an absorbent surface the oil will soak in and leave the pigment on the outside; and if there is not more oil than the wood will absorb there will be none left to bind the pigment together and it will easily rub off. To provide against this, the priming coat is made with much oil and little

pigment; this makes a thin paint which spreads over a large surface. The mixed-paint manufacturers advise adding half a gallon to a gallon of oil to a gallon of their (average) paint; this paint contains some turpentine; using paste white-lead it is a good practice to add to a hundred pounds of this paste four gallons of oil and two of turpentine, with a little drier; this makes about nine gallons of paint; it is to be remembered that the paste lead contains a gallon of oil, so that there is five-ninths of a gallon of oil and two-ninths of a gallon of turpentine in each gallon of this paint. But for pitchy wood like Southern pine or cypress it is probably better to add to the hundred pounds of paste lead three gallons each of oil and turpentine. The latter liquid has a solvent action on pitch, and while it does not remove it, it naturally penetrates the wood, having a sort of affinity for the resinous matter, and carries

with it some of the oil, which remains as a filler when the turpentine has evaporated and by its presence helps that part of the paint which remains outside to stick to the surface. Because of this attraction between the spirit of turpentine and the pitchy matter in the wood, in which respect it is greatly superior to benzine, it is much better than benzine (or other substitute) for the priming coat. The turpentine substitutes are allowable for cases where their function is only to thin the paint. In a priming coat a part only of the use of the turpentine is to thin the paint; it is desired to have but a little pigment on the surface, and only enough oil to bind that into a hard solid film, and in fact a gallon of this thin paint containing but eleven pounds of pigment, in spite of the absorption, will cover about six hundred square feet.

Elastic-Undercoat Cracks

The fundamental principle of all painting or varnishing is that each succeeding coat must be more elastic than the one next under it. Probably the principal reason for this is that the effect of light and air is to harden the film, and the under coats are protected from action somewhat by the coatings over them; hence by properly proportioning the different layers we should be able to get a composite film which should eventually after being fully acted on by light and air, be equally hard and equally yielding throughout; such a covering would not be torn to pieces by changes in temperature or other strain; but if the under coat is elastic while the outer one is hard, it will not afford uni-

form support for the latter, which will crack when suddenly cooled, the cracks, or checks, extending down to the yielding sub-stratum. Such are known to the workmen as elastic undercoat cracks, and most cracks are of this nature; varying the composition of the different layers, though a great help to durability, is not a complete and perfect remedy for the changes time brings about. The carriage painter who is not restricted to the amount of labor fills the porous wood with a hard, unyielding silicious pigment, cemented in by a little very hard binding material; three or four coats of this sort are applied, then sandpapered or pumiced to a perfectly smooth and firm surface, fit it to support the complex covering of paint and varnish used later. The house-painter cannot afford to do all this, and he does the best he can with the limited range of materials and the moderate expense for labor which are allowed

him; he softens the pitchy matters in the wood with turpentine, fills the inner pores with oil, which binds the rather hard paint that remains on the surface to the small depressions and ridges of the grain of the wood, and makes a thin but effective foundation for the second or "body" coat. This priming coat is the most important of all, for the worst defect a paint can show is to scale off the wood in flakes; some painters think well of the best and finest French ochre as a pigment for a priming coat, but the cheap and variable ochres commonly sold, which are made mostly for color and filling for cheap paints such as are used on outbuildings, make dry and floury surfaces from which the following body coat easily splits off. Labor is the chief expense in painting, and it is always best to use the safest and most suitable material. All paint manufacturers agree to this; and just as nearly all

makers of paints for structural steel approve of red-lead as a priming coat, so no one seriously objects to white-lead as a primer for wood in house-painting, no matter what he may elect to put on over it.

Priming Coat

It is also agreed that the first coat should be well brushed into the wood, some even going so far as to desire the use of worn and stubby brushes, the bristles of which are stiff, to rub the paint in more thoroughly. The use of such brushes is generally approved for the first coat in a repainting job, on old painted surfaces.

Knots are often—generally—accompanied with excessive quantities of pitch, which if

painted like the rest of the wood will penetrate the paint and make unsightly and unsound spots in the paint. They are a source of much trouble. The common method of treating them is to apply a thick coating of shellac varnish to the knot before any paint is used; the idea being that as shellac does not dissolve or mix with pitch or oil, it may hinder it from coming out; but it is not satisfactory, though in most cases probably the best thing available.

English Practice

In England where it is common to apply four coats of paint to new work, the priming coat is red-lead in the best work, and a heavy coat of red-lead on a knot is said to be effi-

cient. Experiments in this country for ten years past have indicated that red-lead is a good primer for pitchy woods; but for actually stopping a knot, it should be made with thirty-three to forty pounds of red-lead (dry red-lead or its equivalent) to the gallon of oil; but this would be too heavy for a priming coat. To cover the bright orange color of this will take three coats of white-lead, althought two coats of tinted lead will do it. When it is possible to use this it is the best treatment known to the writer; except, as has been pointed out by several high authorities, if the house can be left unpainted for a year or so the exposure to the weather will take out the resinous matter and the whole surface of the wood will be put in the best possible condition to paint. But this solution of the problem is not often possible; probably shellac is the best thing generally available. Some good painters apply to a

surface of resinous wood a coat of japan drier thinned with turpentine; it does not appear to injure the paint which is afterward used, and is said to be a good treatment.

Body Coat

The second or body coat contains half as much again lead in a gallon as the priming coat; to a hundred pounds of paste white-lead add a gallon and a half each of oil and turpentine, and a pint of drier. This makes a thicker and more opaque coat, and although it contains in a gallon only half as much oil as the first, it is expected to be more elastic because most of the oil in the other coat sank into the wood. Before this coat is applied it is necessary to go over the surface and

putty up all nail-holes and the like, usually with ordinary putty for the exterior and with so-called white-lead putty for the interior. True white-lead putty is made by working dry white-lead into paste lead until the mass becomes putty; this is often used in carriage finishing; but house painters add dry whiting to paste white-lead to make a composition putty which they like better. Ordinary putty is supposed to be composed of whiting and linseed oil; but it is shamelessly adulterated, using marble dust for whiting and all sorts of substitutes, even mineral oil, for the oil; these substitutes are an injury to anyone who uses them, and it is generally safer to make putty when needed by hand; a man can make all the putty used on an ordinary house in two or three hours. Good putty is permanent. On outside work the putty is crowded into the holes with a steel putty-knife, but on interiors, where the surface consists

largely of moldings, a steel knife is liable to leave marks and wooden spatulas or sticks of suitable shapes should be used. If the putty is applied before the priming coat some of the oil will be absorbed by the wood and leave the putty dry and crumbly; so it is always used after a priming coat of some sort.

It is expected that the second coat will dry with a flat surface; but if it has any gloss this should be removed by rubbing lightly with sandpaper, steel wool, curled hair, or even a handful of excelsior. Paint does not adhere well to a glossy surface; and on fine interior work light rubbing should always be practiced. In fact, on fine interiors four coats, brushed out thin and rubbed, should be the rule. The same amount of paint used in four coats will be better in every way, except labor cost, than in three; if two body coats are used the second of them

(third coat) should be a little but not much more elastic than the one beneath it. It is a rule of general application in painting and varnishing that a larger number of thin coats give a better and more lasting result than a small number of thick ones.

Finishing Coat

When the body coat (or coats) is dry and in proper condition, the finishing coat is applied. This contains to a hundred pounds of white-lead paste three and a half to four and a half gallons of oil, a pint of turpentine and a pint of drier. The latter two ingredients, amounting together to a quart, have nearly a half as much thinning effect as the whole of the oil, and they help not only in

spreading and drying the paint, but in making it adhere to the hard body coat. This last coat dries with a gloss; and while this effect may not be preferred for interiors, where it can be removed after the paint gets thoroughly hard and dry by pumicing or light sandpapering, the natural gloss resists the weather much better than a flat finish.

Ott Method

Some years ago considerable attention was attracted to the practice of a successful painter named Ott, in Wilmington, Del. This man had formerly been a carriage-painter, and had left that work to go into house-painting without any previous practice in the latter work, so he applied the principles he

had learned to the later undertaking. In effect, he used a thicker priming coat and harder paint for all coats than has been heretofore described. For a priming coat he thinned paste lead with a mixture of a gallon of oil and about three gallons of turpentine and drier, making only about two-thirds as much paint as the formula which has already been given; hence a thicker and a harder coat. The second coat was the same, but as some of the oil of the first had soaked into the wood, the second coat was more elastic; and the finishing coat was about the same as in the more common practice. The writer of this was one of a committee who inspected about a hundred houses which had thus been painted from two to nine or ten years and it was the unanimous opinion that they were in exceptionally good condition; not only absolutely so but in comparison with similar neighboring houses which had been painted

with the same lead by the same journeymen working for other master-painters who adhered to the more standard practice described in the earlier pages. The paint was hard, it chalked very little, and it stood well even on doorsteps. Whether this would be equally successful in regions where the temperature is very low in winter, or where the atmosphere is dry, is not known. The writer is of the belief that this practice has not become largely used; but it certainly was successful in these cases, and is worthy of remembrance. For painting on metal, such as eave-troughs and down-spouts, this ought to be good practice, for the priming coat does not soak in and ought to be firm and hard; these objects require thorough and frequent attention, and it is apparently impossible to paint the interior of a down-spout; but in the town where the writer lives this is done in the following manner: A stout

string with a stone tied to the end is let down from the top to the bottom, when it is tied to a sponge just large enough to fill the spout; then a suitable quantity of thick paint is poured in at the top; and the sponge is pulled up; this paints the interior. It dries all right because the sun heats the spout and causes a current of air to pass up through it. It may not be very smooth and uniform, but no one can see in to criticize it, and the paint is put where it is needed.

Interior Painting

New interior woodwork is painted with rather harder paint—less oil—than exterior; for priming coat, to 100 pounds paste lead use three gallons of oil and four of tur-

pentine, with one and a half to two pints of drier; the body coat will be the same as for outside work, and the finishing will have three to three and a half gallons of oil, a quart of turpentine, and a pint to a pint and a half of drier; if the building is not heated use more turpentine in cool or damp weather, as in the spring of the year.

Repainting

Old exterior woodwork is supposed to get two coats, the first containing to 100 pounds lead two gallons each of oil and turpentine, being a little more elastic than the body coat for new work; the finishing coat is the same as the finishing coat for new outside work. Old interiors get a hard under coat contain-

ing one gallon of oil and two of turpentine, with finish as before; but in all interior work the formula is for a gloss finish; if what is desired is an egg-shell gloss, instead of three gallons of oil, use only three pints and for a flat finish one pint, and in each of the latter two use two gallons of turpentine and half a pint of drier; all these for finishing coats. For properly aged and dry plastered walls, which absorb the vehicle more than wood, use to 100 pounds of lead seven gallons of oil and a gallon of turpentine for a priming coat; the body coat is the same as has been given, and the thin coat for gloss takes three gallons of oil and one of turpentine; for egg-shell gloss a gallon of oil and two and a half of turpentine; for a flat finish no oil, but a pint of pale enamel varnish with two and a half gallons of turpentine. Fresh and damp plastered walls ought not to be painted.

It sometimes happens that in repainting it

is desirable to paint wood-work, especially doors that have been stained with a red dye to resemble mahogany. This red will generally strike through any number of coats of paint. To prevent this, the whole of such surfaces should be well varnished with pyroxylin varnish, sometimes called collodion; it should be pure pyroxylin dissolved in amyl acetate, and contain no resin. Substitutes for this are sold as bronze powder and aluminum paint liquids which are perfectly useless for the present purpose. The straight amyl acetate collodion or pyroxylin varnish is the only thing known to the writer that will stop these aniline reds from coming through.

Special Uses of White-Lead

White-lead is used in various special ways in painting, as for example in what the carriage-painters call "rub-lead," which is paste lead thinned to a brushing consistency with a mixture of oil and japan drier. This mixture is made with one to three parts oil to one part japan. This is applied with a brush and when it has set and is stiff it is rubbed into the wood with the palm of the hand or the ball of the thumb. If it is to be covered with a colored paint, the rub-lead is either tinted to match or it has enough lamp black put in to give it a slate-color; lamp black is thought to add smoothness and better working quality to the lead. This gives a fine solid surface which can be sandpapered in two or three days.

Knifing lead is made of two or three parts of dry and one of paste white-lead mixed to a softy putty with a mixture of equal parts of rubbing varnish and japan. This can be worked into flat surfaces with the blade of a putty knife; or it may be thinned to a paint with turpentine and applied with a brush, and when it has set work it in with a knife; always clean off any surplus. This is more rapid than rub-lead. Both these methods of filling give non-porous, solid surfaces, fit to be sandpapered and are only used when a fine finish, requiring sandpapering or pumicing, is desired. A small proportion of white-lead is also a necessary ingredient of a filler called "rough-stuff" used by carriage painters; but this is essentially a silicious filler. Ships and boats are often painted with white-lead. For the upper part of a large vessel the "Ott method" may be recommended, because a moist atmosphere tends to

soften paint; the part exposed to the waves should have two or three thin, well-dried-on coats of a very heavy red-lead paint, over which a number of coats, enough to cover up the red color, of hard white-lead paint should be used. It is not uncommon for the owner of a fine yacht or row-boat to put on two or three finishing coats, one over another, all made as follows: The paste white-lead is thoroughly mixed with two or three times its volume of turpentine, let stand overnight, and the turpentine poured off; this takes away more than half of the oil originally in the paste. The remainder, which is the while-lead with a little oil in it, is mixed to paint consistency with turpentine. This has so little binder in it that its surface readily washes off, leaving a pure white as long as any is left. This prevents the floating tarry material common in harbor waters from dirtying the boat; but it needs to be repainted

every few weeks. The painting of a boat depends entirely on the amount of time and money the owner wishes to spend on it.

Canvas decks (or roofs) are laid as follows: The canvas is tightly stretched and nailed down, no attention being paid to small wrinkles but these must not be allowed to gather into large ones; then it is thoroughly wet with clean water, which shrinks the cloth so that it is perfectly taut, and the small wrinkles all disappear. Before it is dry it is painted with a heavy white-lead paint; the wet cloth does not absorb much oil, yet enough to bind the paint firmly. If it is allowed to get dry before painting it should be treated as soft spongy wood, with an oily priming coat.

The paint dries rapidly in sunny hot weather but each coat must dry well before a following one is put on.

Linseed Oil

In this book when oil is mentioned the so-called "raw" or untreated linseed oil is meant. What is known as boiled oil, is the same oil to which has been added a little "drier," which in this case is a mixture of three to nine parts of litharge or red-lead and one of oxide of manganese; the amount of this mixture is from one to two per cent of the weight of the oil (most of this is not absorbed), and the oil and drier heated to from 450° to 500° F. four to six hours or longer, with constant stirring. Some make boiled oil with only lead, and some with only manganese. Lead dissolves more rapidly; and with a mixed drier the dissolved manganese finally amounts to about a tenth as much as

the dissolved lead. Some excellent boiled oil is made with a cobalt drier.

A more scientific way is to dissolve one part of manganese and five to ten parts of lead (as oxides) in five to ten times as much oil as is necessary to chemically combine with them; this is done by heat; then add enough of this soluble drier, called crushers' drier because made for those who crush the seed and extract the oil, to make a fifth of one per cent of lead and a twentieth of one per cent of manganese, of the weight of the oil, and heat the whole to from 500° to 600° F. several hours. If a large tank of oil is heated it will take many hours for it to cool.

There is a great variety of such products; in general it may be said that cooking oil at a high heat makes it more like a varnish; it dries with a gloss, and is more resistant to water; it also dries quickly. For general use it is not thought to be as easy to work with

a brush as raw oil, and perhaps is not as durable; it is better than raw oil for under-water objects, and half raw and half boiled oil is used for exterior house-painting quite extensively; no other drier is used, and the paint has a better gloss than if all raw oil is used. Plain, untreated linseed oil takes five to six days to dry; hence the painter always adds a drier (often called a japan drier) to it; this is a solution of lead or manganese or lead and manganese, in oil, and thinned with turpentine (or substitute) so that if one part of it is added to nine or ten parts of raw oil the film will dry in twelve to twenty-four hours; but it takes considerably more time than this for it to get hard all through.

Not much oil is now heated over an open fire in a kettle; the most of it is heated in large tanks furnished with steam coils, and agitated with mechanical stirrers or by blowing a little air through continually while cook-

ing. There is nevertheless a prejudice in favor of kettle-boiled oil; probably because some of this oil gets heated far above the nominal temperature in the portions which come in immediate contact with the bottom of the kettle over the fire; and this produces more gloss, and a highly heated oil is not as easily softened by water (hydrolyzed) as is one having less of a varnish-like character. Linseed oil which has long been heated to a high temperature is often called oil-varnish. But if heated too much, oil becomes a jelly of no use to painters, but necessary in making some kinds of oil-cloth and for patent-leather. For ordinary exterior painting the use of a part of boiled oil may be recommended for a damp climate or location.

Color of Houses

The final word in relation to white-lead is that it is not generally white, as it is actually used. More than half of the houses painted with it are tinted with some color; partly because such paint usually wears longer, partly because white is not a suitable color for the smoky air of cities, and chiefly because the owners prefer, on æsthetic grounds, to select some color which contrasts or harmonizes with those nearby, or with features of the landscape. A moderate proportion of white houses is all right; but who would have everything just alike? Who would have them all gray, or buff, or pale green, or any other single color? And it is so easy to have any color you like. One per cent or less of a suitable tinting color with white-lead will

give any light color; five per cent, or in extreme cases ten, will produce medium tones; and even dark colors take not more than ten to twenty per cent of pure paste colors ground in oil. These are easily mixed in the manner already described; all good painters do it continually, and the amateur can learn with a little practice on a small scale. Formulas and color cards, which indicate how the results are to be secured, are to be had from any of the manufacturers or dealers; having this simple knowledge, a wide field for the exercise of individual taste and choice is open; and the pleasure of being satisfied is one that does not grow dull with time. This personal element is properly one of the chief attractions in the use of white-lead.

Table showing the COST OF WHITE-LEAD PAINT per gallon. Figures show the cost of quantities of each ingredient required to make one gallon of paint according to the formulas on the lower half of the sheet. The cost of one gallon of paint is the sum of the proper figures in each of the three sections of cost of lead, oil and drier, and turpentine. For instance, the cost of a gallon of paint made according to Formula A 1, with white lead at 13 cents per pound, oil and drier at $2.20 per gallon and turpentine at 2.00 per gallon, would be $1.44 + $1.01 + $0.44, or $2.89.

COST OF WHITE LEAD PLUS COST OF OIL AND DRIER PLUS COST OF TURPENTINE — COMPOSITION OF PAINT

Cost of White Lead — For Cost of White Lead in a Gallon of Paint, Look under Proper Price Column Below. White Lead Price per Pound in Cents

Formula No	7 cts.	8 cts	9 cts	10 cts.	11 cts.	12 cts	13 cts	14 cts.	15 cts.	16 cts.
A 1	78	89	1 00	1 11	1 22	1 33	1 44	1 55	1 67	1 78
A 2	1 17	1 34	1 50	1 67	1 84	2 00	2 17	2 34	2 51	2 67
A 3	1,00	1 14	1 29	1 43	1 57	1 72	1 86	2 00	2 15	2 29
B 1	1 00	1 14	1 29	1 43	1 57	1 72	1 86	2 00	2 15	2 29
B 2	1 00	1 14	1 29	1 43	1 57	1 72	1 86	2 00	2 15	2 29
C 1	70	80	90	1 00	1 10	1 20	1 30	1 40	1 50	1 60
C 2	1 17	1 34	1 50	1 67	1 84	2 00	2 17	2 34	2 51	2 67
C 3a	1 17	1 34	1 50	1 67	1 84	2 00	2 17	2 34	2 51	2 67
C 3b	1 33	1 52	1 71	1 90	2 09	2 28	2 47	2 66	2 85	3 04
C 3c	1 17	1 34	1 50	1 67	1 84	2 00	2 17	2 34	2 52	2 67
D 1	1 17	1 34	1 50	1 67	1 84	2 00	2 17	2 34	2 51	2 67
D 2a	1 14	1 30	1 47	1 63	1 79	1 96	2 12	2 28	2 45	2 61
D 2b	1 33	1 52	1 71	1 90	2 09	2 28	2 47	2 66	2 85	3 04
D 2c	1 40	1 60	1 80	2 00	2 20	2 40	2 60	2 80	3 00	3 20
E 1	64	73	82	91	1 00	1 09	1 18	1 27	1 37	1 46
E 2a	1 17	1 34	1 50	1 67	1 84	2 00	2 17	2 34	2 51	2 67
E 3a	1 00	1 14	1 29	1 43	1 57	1 72	1 86	2 00	2 15	2 29
E 3b	1 08	1 23	1 39	1 54	1 69	1 85	2 00	2 16	2 31	2 46
E 3c	1 27	1 46	1 64	1 82	2 00	2 18	2 37	2 55	2 73	2 91

Cost of Oil and Drier — For Cost of Oil and Drier in a Gallon of Paint, Look under Proper Price Column Below. Price of Oil and Drier per Gallon

Formula No	60 cts	80 cts	$1 00	$1 20	$1 30	$1 40	$1 50	$1 60	$1 70	$1 80	$2 00	$2 20	$2 40	$2 60
A 1	27	37	46	55	60	64	69	73	78	82	92	1 01	1 10	1 19
A 2	16	22	27	33	35	38	41	43	46	.49	54	60	65	70
A 3	35	47	59	71	77	82	88	94	1 00	1 06	1 18	1 30	1 41	1 53
B 1	18	24	30	36	39	42	45	48	52	55	61	67	73	79
B 2	35	47	59	71	77	82	88	94	1 00	1,06	1 18	1 30	1 41	1 53
C 1	19	26	32	38	41	45	48	51	54	57	64	70	77	83
C 2	16	22	27	33	35	38	41	43	46	49	54	60	65	70
C 3a	32	42	53	63	69	74	79	85	90	95	1 06	1 16	1 27	1 38
C 3b	04	06	07	09	09	10	11	11	12	13	14	16	17	18
C 3c	02	02	03	04	04	04	05	05	05	06	06	07	07	08
D 1	11	15	19	23	24	26	28	30	32	34	38	41	45	49
D 2a	31	41	51	61	66	71	77	82	87	92	1 02	1 12	1 22	1 33
D 2b	05	07	08	10	11	12	12	13	14	15	17	18	20	22
D 2c	02	03	.04	05	05	05	06	07	07	07	08	08	09	10
E 1	38	51	64	76	83	89	95	1 02	1 08	1 15	1 27	1 40	1 53	1 65
E 2a	16	22	27	33	35	38	41	43	46	49	54	60	65	70
E 3a	27	36	45	54	58	62	67	71	76	80	89	98	1 07	1 16
E 3b	10	13	16	19	21	22	24	25	27	29	32	35	38	41
E 3c	02	03	03	04	04	05	05	05	06	06	.07	07	08	09

Cost of Turpentine — For Cost of Turpentine in a Gallon of Paint, Look under Proper Price Column Below. Price of Turpentine per Gallon. **Composition of Paint**

Formula No	30 cts	40 cts	60 cts	80 cts	$1 00	$1 20	$1 40	$1 60	$1 80	$2 00	$2 20	$2 40	Wt. per Gal. Lbs.	Paste White Lead in a Gal Lbs.	Oil and Drier in a Gal Gal	Turpentine in a Gal Gal.
A 1	07	09	13	18	[illegible]	27	.31	36	40	44	49	53	16 3	11 1	458	222
A 2	08	10	15	20	[illegible]	.30	.35	.40	45	50	55	60	20.6	16 7	271	250
A 3	01	01	01	01	[illegible]	02	.02	.03	03	03	04	04	19.0	14 3	589	017
B 1	09	11	17	23	[illegible]	34	40	46	51	57	63	[illegible]	18 7	14 3	303	286
B 2	01	01	01	01	[illegible]	02	02	03	03	03	.04	04	19.0	14 3	589	017
C 1	12	16	24	32	40	48	56	64	72	80	88	96	15.4	10 0	319	400
C 2	08	10	15	20	25	30	35	40	45	50	55	60	20 6	16 7	271	250
C 3a	01	02	03	03	04	05	06	07	08	08	09	10	20 8	16 7	579	042
C 3b	11	15	23	30	38	46	53	61	69	76	84	91	22 4	19 0	071	381
C 3c	15	20	30	40	50	60	70	.80	90	1 00	1 10	[illegible]	.20 5	16 7	031	500
D 1	10	13	20	27	[illegible]	40	47	53	60	67	73	80	20 5	16 7	.188	333
D 2a	01	02	03	03	04	05	06	.07	07	08	09	10	20 6	16 3	510	041
D 2b	11	15	23	30	38	46	53	61	69	76	84	91	22 4	19 0	083	381
D 2c	12	16	24	32	.40	48	56	64	72	80	88	96	23 1	20 0	038	400
E 1	03	04	05	07	09	11	13	15	16	.18	20	[illegible]	14 7	9 1	636	091
E 2a	08	10	15	20	25	30	35	40	[illegible]	50	55	60	20 6	16 7	271	250
E 3a	04	06	09	11	14	17	20	23	[illegible]	29	31	[illegible]	18.8	14 3	416	143
E 3b	12	15	23	31	39	46	54	62	69	77	85	[illegible]	19 4	15 4	159	385
E 3c	.14	18	27	36	45	54	64	73	82	91	1,00	[illegible]	21 7	18 2	034	454

PAINTING FORMULAS

TABLE A—NEW, UNPAINTED WOOD OUTSIDE

Ingredients	A 1 Priming Coat	A 2 Second Coat	A 3 Third Coat
Paste white lead	100 pounds	100 pounds	100 pounds
Pure raw linseed oil	4 gallons	1½ gallons	3½-4½ gallons
Pure turpentine	2 gallons	1½ gallons	1 pint
Drier free from rosin	1 pint	1 pint	1 pint
How much paint it makes	9 gallons	6 gallons	6¾-7¾ gallons
Square feet it will cover	5,175 sq. ft.	3,600 sq. ft.	3,900-4,500 sq. ft.

TABLE B—REPAINTING OLD PAINTED WOOD OUTSIDE

Ingredients	B 1 First Coat	B 2 Second Coat
Paste white lead	100 pounds	100 pounds
Pure raw linseed oil	2 gallons	3½-4½ gallons
Pure turpentine	2 gallons	1 pint
Drier free from rosin	1 pint	1 pint
How much paint it makes	7 gallons	6¾-7¾ gallons
Square feet it will cover	4,200 sq. ft.	3,900-4,500 sq. ft.

TABLE C—NEW, UNPAINTED INTERIOR WOODWORK

Ingredients	C 1 Priming Coat	C 2 Second Coat	C 3a Third Coat, Oil Gloss Finish	C 3b Third Coat, Egg Gloss Finish	C 3c Third Coat, Flat Finish
Paste white lead	100 pounds	100 pounds	100 pounds	100 pounds	100 pounds
Pure raw linseed oil	3 gallons	1½ gallons	3-3½ gallons	3 pints	1 pint light enamel varnish
Pure turpentine	4 gallons	1½ gallons	2 pints	2 gallons	3 gallons
Drier free from rosin	1½-2 pints	1 pint	1-1½ pints	½ pint	½ pint
How much paint it makes	10 gallons	6 gallons	6-6½ gallons	5¼ gallons	6 gallons
Square feet it will cover	5,750 sq. ft.	3,600 sq. ft.	3,600-3,900 sq. ft.	3,150 sq. ft.	3,600 sq. ft.

TABLE D—REPAINTING PAINTED INTERIOR WOODWORK

Ingredients	D 1 First Coat	D 2a Second Coat, Oil-Gloss Finish	D 2b Second Coat, Egg-shell Gls. Fin.	D 2c Second Coat, Flat Finish
Paste white lead	100 pounds	100 pounds	100 pounds	100 pounds
Pure raw linseed oil	1 gallon	3-3½ gallons	3 pints	1 pint
Pure turpentine	2 gallons	2 pints	2 gallons	2 gallons
Drier free from rosin	1 pint	1-1½ pints	½ pint	½ pint
How much paint it makes	6 gallons	6½-6¾ gallons	5¼ gallons	5 gallons
Square feet it will cover	3,600 sq. ft.	3,675-4,050 sq. ft.	3,150 sq. ft.	3,000 sq. ft.

TABLE E—DRY UNPAINTED (NOT FRESH) PLASTER WALLS

Ingredients	E 1 Priming Coat	E 2 Second Coat	E 3a Third Coat, Oil-Gloss Finish	E 3b Third Coat, Egg-Shell Gloss	E 3c Third Coat, Flat Finish
Paste white lead	100 pounds	100 pounds	100 pounds	100 pounds	100 pounds
Pure raw linseed oil	7 gallons boiled oil	1½ gallons raw oil	3 gallons (raw)	1 gallon (raw)	1 pint light enamel varnish
Pure turpentine	1 gallon	1½ gallons	1 gallon	2½ gallons	2½ gallons
Drier free from rosin	None	1 pint	1 pint	½ pint	½ pint
How much paint it makes	11 gallons	6 gallons	7 gallons	6¾ gallons	5¼ gallons
Square feet it will cover	6,325 sq. ft.	3,600 sq. ft.	4,200 sq. ft.	3,900 sq. ft.	3,300 sq. ft.

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